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Formation of the charged domain walls in lithium niobate single crystals with various electrode types

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Magnesium oxide doped lithium niobate single crystals (MgO:LN) are one of the most popular materials for nonlinear-optical applications. It was shown earlier, that during polarization reversal with metal electrodes domains with conductive charged domain walls penetrate through the crystal, leading to decreasing of applied electric field and strongly influencing the periodical poling process [1]. We have shown that this effect is absent for liquid electrolyte electrodes.

We present here the experimental study of the domain structures formed during polarization reversal in MgO:LN single crystals with a various combinations of electrodes at the polar surfaces. Several types of electrodes have been used: the sputtered ITO or Cr thin films with thickness 100-200 nm ("solid electrodes") and saturated water solution of LiCl ("liquid electrodes"). Domain kinetics was visualized *in situ* during polarization reversal with a simultaneous recording of the switching current. The integral conductivity of the obtained domain structures was measured immediately after the polarization reversal. The obtained static domain structures have been investigated by means of Cherenkov Second Harmonic Generation microscopy in the crystal bulk [2], and the complete three-dimensional domain shape was reconstructed.

It was shown that the spike-like domains with charged head-to-head walls appeared for negative polar surface (Z-) covered by solid electrode - metal or semiconductor sputtered film. The charged walls of the created domains possess pronounced conductivity. The domain sideways growth and merging are essentially suppressed in this case. In contrast individual domains merge creating the uniform right-angle prismatic domains with almost vertical low conductive walls at the termination of the switching process for Z- surface covered by liquid electrolyte.

For positive (Z+) polar surface covered by solid electrode the domain backswitching after external field switch-off leads to increase of domain walls inclination angle and higher conductivity along the charged walls due to more pronounced shrinkage at the Z- surface. For Z+ polar surface covered by liquid electrolyte electrode the conductivity along the walls is unipolar and current flow through the wall results in reduction of cations. This effect allowed realizing "domain wall lithography" by direct electrodeposition of metal on the domain walls.

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